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EXAMINED

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SL NO :- 1

Experiment NO :- 12

Date :- 02/07/2022

Experiment Name :- To determine the
Boltzman constant using V-I
characteristics of PN junction
diode.

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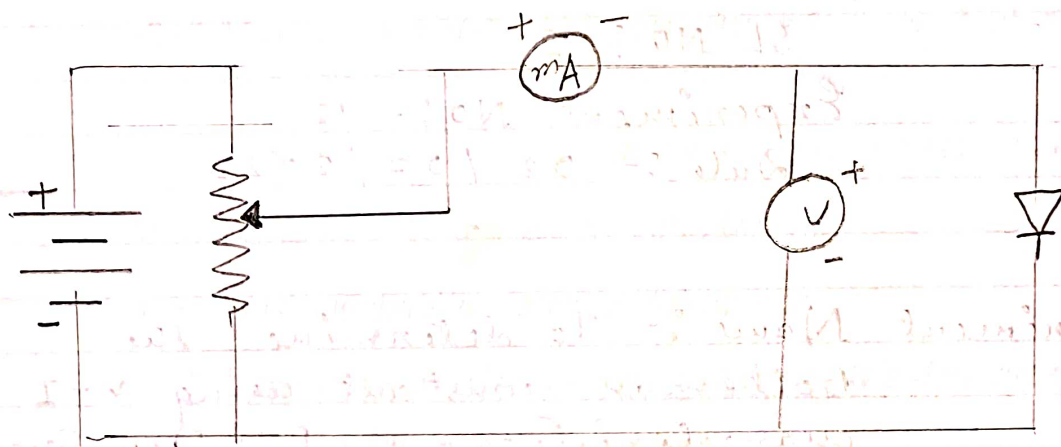


Fig:- circuit diagram for determination of Boltzmann constant

Theory :-

When a positive potential is applied to the p-side of a p-n junction diode with respect biased as n-side, the diode is said to be forward as discussed earlier. If V is the voltage across the junction the diode current I is given by:

$$I = I_0 \left[\exp \frac{qV}{\eta kT} - 1 \right] \quad \text{--- (1)}$$

where I_0 is the reverse saturation current q is the electronic charge k is the Boltzmann constant, T is the absolute temperature and ' η ' is the numerical constant depending on the material of the diode. For germanium $\eta=1$ and for silicon $\eta=2$

For a silicon diode at room temperature ($T=300\text{ K}$) eqn (1) reduces to

$$I = I_0 \left[\exp (19.3 V) - 1 \right] \quad \text{--- (2)}$$

where ' V ' is the voltage across the diode in volt.

For a positive voltage values $0.5 - 1\text{ V}$, the exponential term varies from 1.55×10^4 to 2.41×10^8 . Hence in this voltage range or above it, we can easily neglect ' I_0 ' in eqn (1) as compared to the exponential

term and can write

$$I = I_s \exp\left(\frac{qV}{\eta kT}\right)$$

$$\text{or } \log_{10} I = \log_{10} I_s + \frac{qV}{2.303 \eta kT}$$

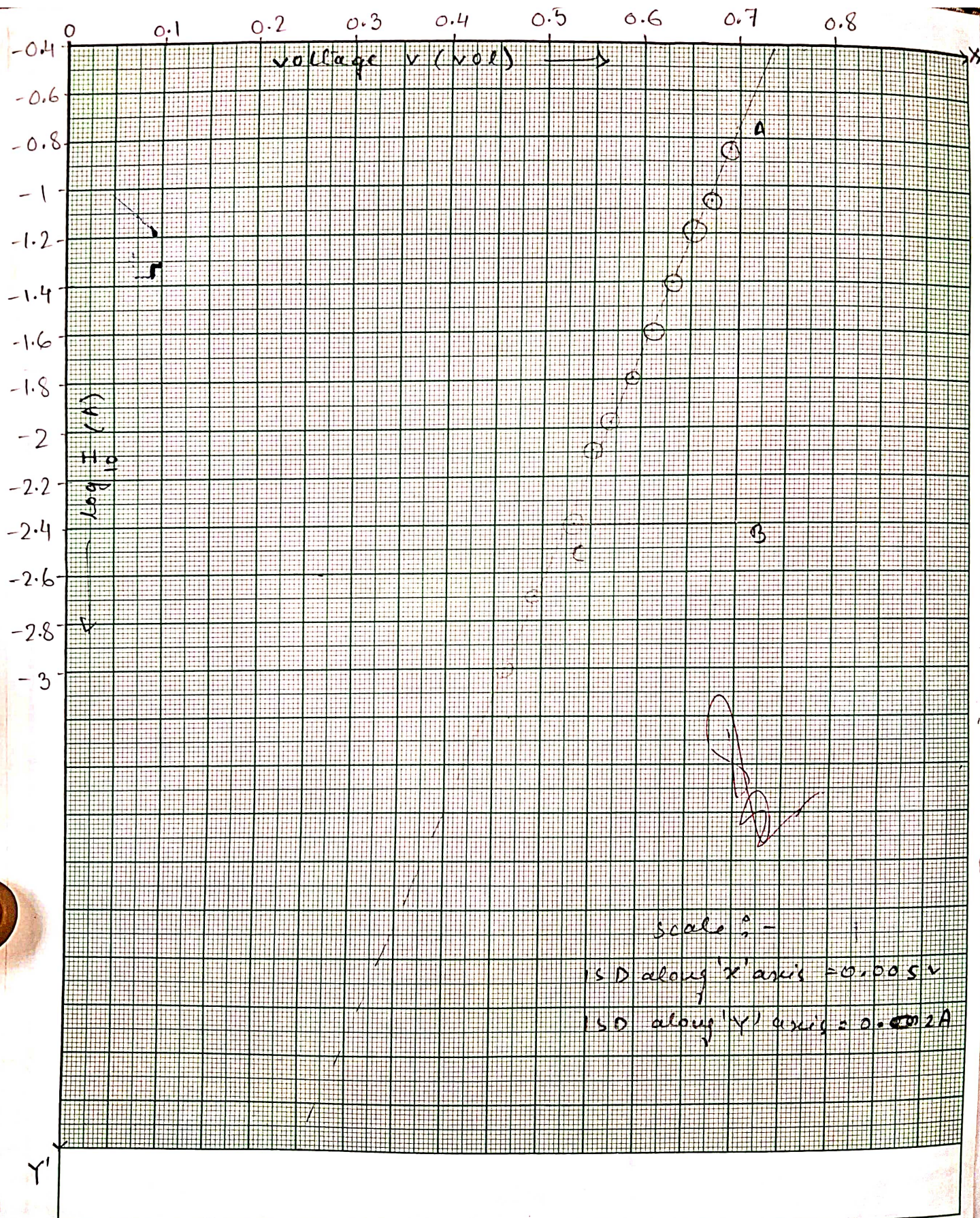
So a plot of $\log_{10} I$ versus V gives $\frac{q}{2.303 \eta kT}$

as the slope from which the Boltzmann constant K can be evaluated easily.

Apparatus :-

SL NO	Name of Apparatus	Range	Small division	Remark.
1	Volt meter	0-10 V	0.01 V	For measuring voltage across diode
2	milliammeter	0-300 mA	1 mA	For measuring current across diode
3	Thermometer	0-100°C	0.5°C	For measuring temperature

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Observations :-

Temperature . $T = 31^{\circ}\text{C} = (31 + 273)\text{K} = 304\text{K}$

Serial No.	voltage in (volts)	Current (mA)	Current, I m (Ampere)	$\log_{10} I$ (A)
1	0	0	0	
2	0.44	0	0	
3	0.46	1	0.001	-3
4	0.49	2	0.002	-2.698
5	0.53	4	0.004	-2.397
6	0.55	8	0.008	-2.096
7	0.57	11	0.011	-1.958
8	0.59	16	0.016	-1.795
9	0.61	25	0.025	-1.602
10	0.63	40	0.040	-1.397
11	0.65	62	0.062	-1.207
12	0.67	85	0.085	-1.07
13	0.69	141	0.141	-0.850

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∴ Calculation :-

The graph between V and $\log_{10} I$ is a straight line.

From graph,

$$\Delta \log_{10} I = 82 \times 0.02$$

$$\Delta V = 35 \times 0.005$$

$$\text{slop} = \frac{\Delta \log_{10} I}{\Delta V} = \frac{82 \times 0.02}{35 \times 0.005} = 9.371$$

from eqnⁿ.

$$\text{slop} = \frac{q}{2.303 \times n k T}$$

$$\begin{aligned} \text{on, } k &= \frac{1.6 \times 10^{-19}}{2.303 \times 2 \times 304 \times \text{slop}} \\ &= \frac{1.6 \times 10^{-19}}{2.303 \times 2 \times 304 \times 9.371} \end{aligned}$$

$$k = 1.22 \times 10^{-23} \text{ J/K}$$

$$q = 1.6 \times 10^{-19} \text{ C}$$

$$n = 2 \text{ for Si}$$

$$T = 31^\circ \text{C}$$

$$= 304 \text{ K}$$

Result :-

The experimentally obtained value of Boltzmann constant is $= 1.22 \times 10^{-23} \text{ J/K}$.

Percentage Error :-

Standard value of Boltzmann constant
 $K_0 = 1.38 \times 10^{-23} \text{ J/K}$

Experimental value of Boltzmann constant
 $= 1.22 \times 10^{-23} \text{ J/K}$

$$\begin{aligned} \text{Percentage error} &= \frac{K_0 - k}{K_0} \times 100\% \\ &= \frac{(1.38 - 1.22) \times 10^{-23}}{1.38 \times 10^{-23}} \times 100\% \end{aligned}$$

$$= \frac{0.16}{1.38} \times 100\%$$

$$= 0.1159 \times 100\%$$

$$= 11.59\%$$

$$\approx 11.6\%$$

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SL NO :- 2

Exp NO :- 2

Date :-

Experiment Name :- To determine the specific
- rotation of sugar solu-
- tion using polarimeter

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Theory :-

Let a plane polarized monochromatic light of wavelength λ pass through a column of solution of length l cm and containing m gm of an active substance per cm^3 at a given temperature. Then the plane of polarization of light is rotated through an angle θ given by

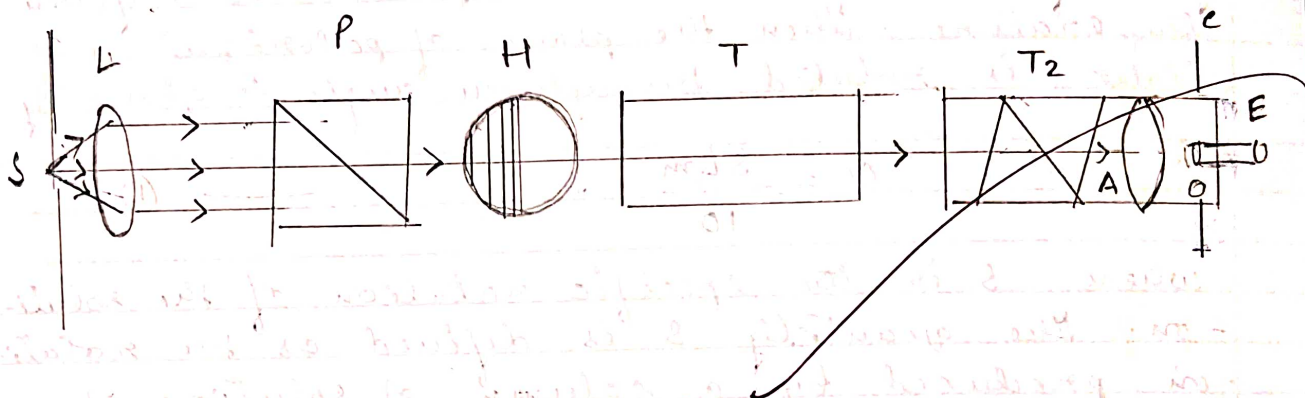
$$\theta = \frac{S l m}{10} \quad \text{--- (1)}$$

where S is the specific rotation of the solution. The quantity S is defined as the rotation produced by a column of solution of length 1 decimetre and containing 1 gm of the active substance per cm^3 of the solution under the experimental condition, i.e., at the temperature of the solution and for the wave length used.

If 100 cm^3 of the solution contains c gm of the active substance, the strength of the solution is $c\%$, and $m = \frac{c}{100}$

Hence,
$$\theta = \frac{S c}{1000} \quad \text{--- (2)}$$

$$S = \frac{1000 \theta}{l c} \quad \text{--- (3)}$$



S - slit

L - collimating lens

P - Polarizing nicol

H - Half shade plate

T - Tube containing solution

A - Analysis nicol

O.E. - objective and eyepiece of the observing

T₂ - Tube housing A and the observing telescope

C - Circular scale on which the vernier
attached to T₂ rotates.

Equation (2) shows that for a given length, the plot of θ versus c will be a straight line. This plot is known as the calibration curve of the polarimeter for the active solution. This plot can be used to find the concentration c of an unknown solution of the same solute by measuring the rotation θ produced by it.

From a set of values of c and θ , and by measuring the length of the tube containing the solution, the specific rotation of the solution, $[\alpha]$, can be determined from Eq (3)

The amount of the solute, m' , required to prepare $v \text{ cm}^3$ of the solution of concentration $c\%$ is given by

$$m' = \frac{cv}{100} \text{ gm}, \quad \text{--- (4)}$$

$$\text{or, } v = \frac{100 m'}{c} \text{ cm}^3, \quad \text{--- (5)}$$

From the solution of a known concentration $c\%$, a solution of a lower concentration $c'\%$ can be prepared by adding $x' \text{ cm}^3$ of water to $x \text{ cm}^3$ of the solution of concentration $c\%$.

$$\text{where, } x' = \frac{c - c'}{c'} x \text{ cm}^3. \quad \text{--- (6)}$$

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Equation (3) (4) (5) and (6) are used as the working formula for the experiment. If θ is measured in degrees ρ will be obtained in degree $\text{cm}^3 \text{ decimeter}^{-1} \text{ gm}^{-1}$

Apparatus and Accessories:-

- (i) Polarimeter
- (ii) Active substance
- (iii) Balance and weights
- (iv) Measuring cylinder
- (v) Flask
- (vi) Distilled water
- (vii) Scale
- (viii) Sodium light source etc.

Experiment Results :-

Table - 1

Preparation of solution of highest concentration
c% by volume

Temperature of the solution = 33°C

Temperature of the solution = 33°C

Volume of the solution to be prepared	Mass of the solute taken to prepare 14% solution	Volume of water to be added to the flask to make the concentration 14%.
100 cc	14 gm	92 cc

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Table - 2

Concentration of solution of concentration $C\%$ into if known lower concentration.

Concentration required $C'(\%)$	Concentration of stock soln $C(\%)$	Volume of the stock soln required taken $x(\text{cm}^3)$	Water to be added to $x\text{cm}^3$ of the stock soln $x' = \frac{(C-C')x}{C'} \text{ cm}^3$	Temp of the soln $(^\circ\text{C})$
12	14	84	14	33 $^\circ\text{C}$
10	12	90	18	
8	10	80	20	
6	8	60	20	

Vernier constant of the Polarimeter :-

1 smallest division of circular scale = 1°

10 vernier scale division = 9 circular scale division

1 vernier scale division = $\frac{9}{10}$ circular scale division

$\therefore$ Vernier constant = $\left(1 - \frac{9}{10}\right) \times 1^\circ$

$$= \frac{1}{10} \times 1^\circ$$

$$= 0.1^\circ$$

Table - 3

No. of observations	Reading of first vernier				Reading of second vernier			
	Main Scale reading (M)	Vernier scale Reading (V)	Total reading T = M + V	Mean	Main Scale Reading (M)	Vernier scale Reading (V)	Total reading T = M + V	Mean Reading
1	359	6	359.6		179	7	179.7	
2	359	5	359.5	359.4	179	4	179.4	179.13
3	359	1	359.1		179	5	179.5	

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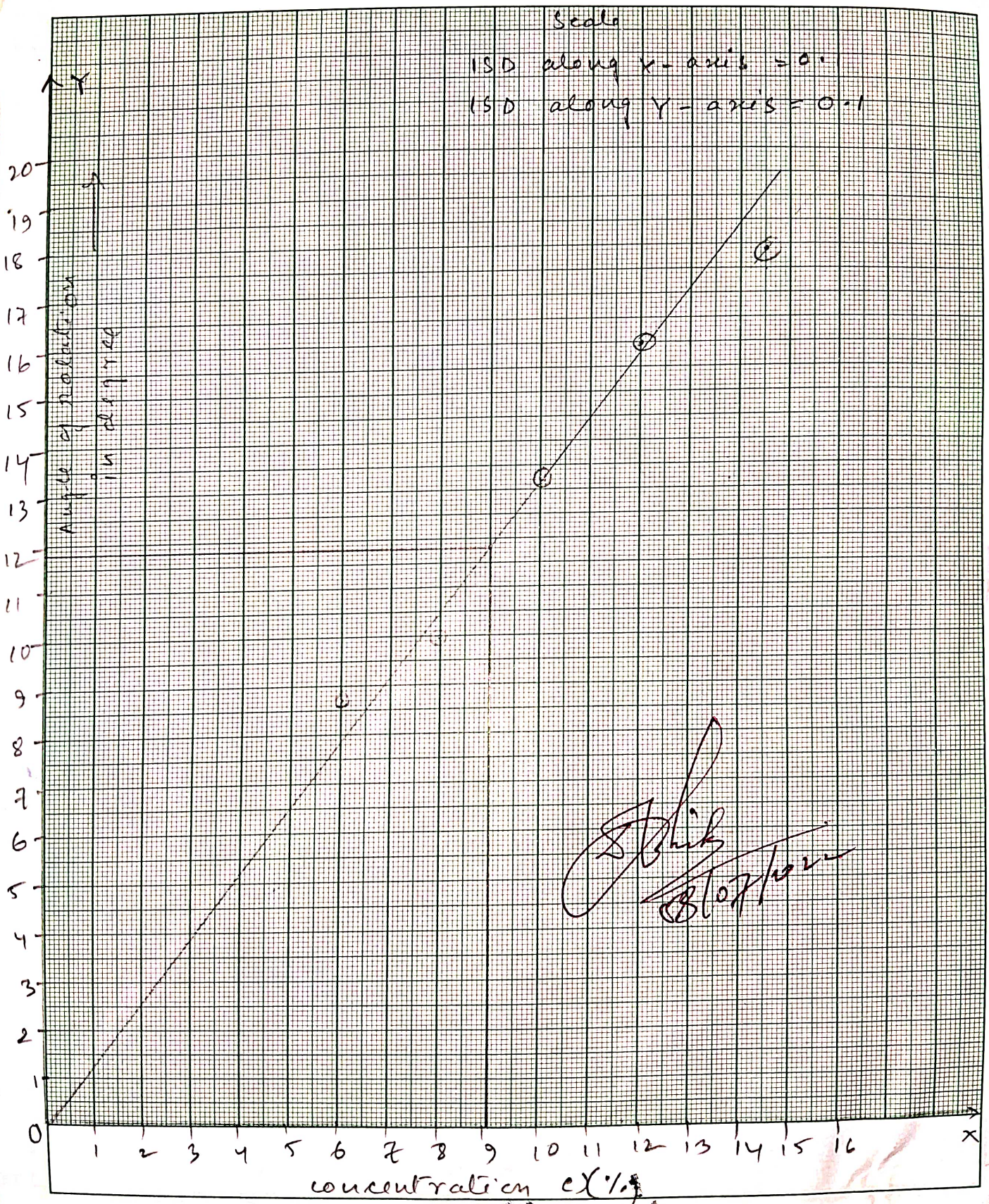


Table - 4

Angle of rotation (θ) verses Concentration (C) data

Concentration of the solution C%	vernier no.	Main scale Reading (M)	vernier heading	Total Reading	Angle of rotation - on from each other.	Mean angle of rotation.
14%	1st	16	9	16.9	17.5°	17.385°
	2nd	196	8	196.8	17.27°	
12%	1st	15	3	15.3	15.9°	15.485°
	2nd	195	6	195.6	16.07°	
10%	1st	12	6	12.6	13.2°	13.185°
	2nd	192	7	192.7	13.17°	
8%	1st	9	5	9.5	10.1°	10.035°
	2nd	189	5	189.5	9.97°	
6%	1st	9	2	8.2	8.8°	8.735°
	2nd	188	2	188.2	8.67°	

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$\therefore$ calculation :-

From graph,

concentration $c = 9\%$.

Angle of rotation $\theta = 11.8^\circ$.

specific rotation

$$s = \frac{1000 \theta}{lc}$$

$$= \frac{1000 \times 11.8}{20 \times 9}$$

$$= 65.55 \text{ degree cm}^3 \text{ decimeter}^{-1} \text{ gm}^{-1}$$

length of the
tube $l = 20 \text{ cm}$

Table - 5

lengths of the tube T between the two inner surface of its end plates.

No of observation	lengths l cm	Mean length l (cm)
1	20	20
2	20	
3	20	

Table - 6

l (cm)	τ (%)	θ (degree)	$S = \frac{1000 \theta}{\text{degree cm}^3 \text{ decimeter}^{-1} \text{ gm}^{-1}}$
20	9	11.8	65.55

Result: Specific rotation of sugar solution is $65.55 \text{ degree cm}^3 \text{ decimeter}^{-1} \text{ gm}^{-1}$

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88/07/2022

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